

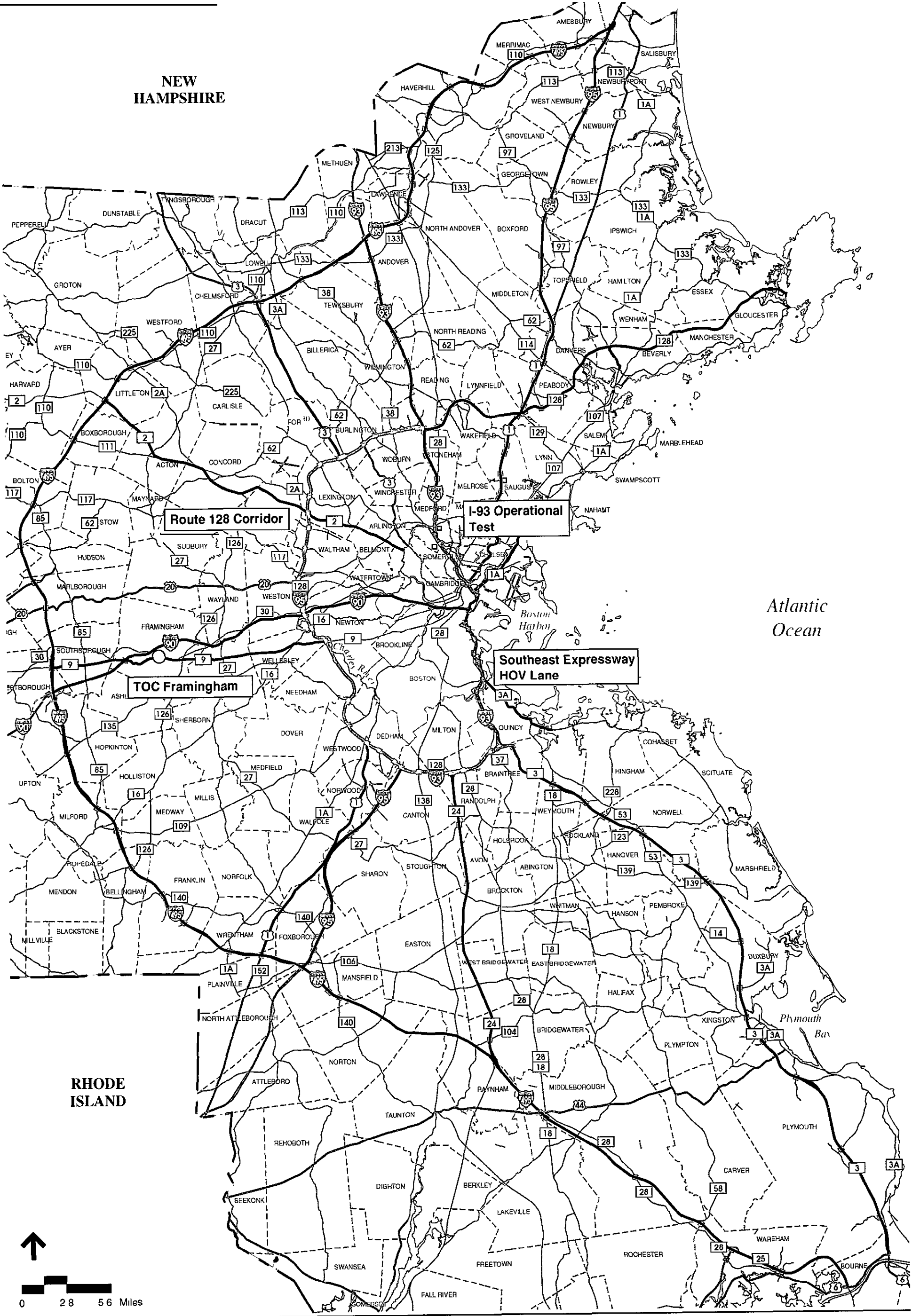
13. SYSTEM IMPLEMENTATION

COSTS

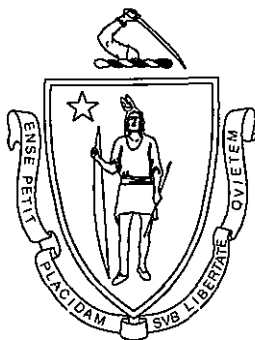
The estimated cost for the recommended Boston area IVHS network is approximately \$91.5 million in capital costs, with a continuing annual operations and maintenance cost of \$12.2 million. A breakdown of these costs by component for Phase 1 and Year 2000 is provided in Exhibit 13-1 and 13-2.

These cost estimates include the following items:

- Loop Upgrade - Installation of a Type 170 (or 2070) controller assembly on existing foundation. Also includes conduit for telephone communications and/or power supply.
- New Loop Detector - Installation of loop pairs in each lane and Type 170 (or 2070) controller assembly on new foundation. Also includes conduits for telephone communications and power supply.
- Overhead Detector - Installation of an overhead detector (microwave or possible radar) over each lane on existing structure, and Type 170 (or 2070) controller assembly on new foundation. Also includes conduits for telephone communications and power supply.
- Overheight Detector - Installation of overheight detector, blank-out sign, support structure, and processor. Also includes conduits for telephone communications and power supply.
- Park-and-Ride Lots - Installation of loops at parking lot entrances and exits, and Type 170 (or 2070) controller assembly on new foundation. Also includes conduits for telephone communications and power supply.
- Weather Sensor - Installation of sensors and remote processing units. Also includes conduits for telephone communication and power supply.
- CCTV - Installation of cameras and lenses, pan/tilt units, poles and foundations, control receiver in cabinet, and connecting cables. Also includes conduits for telephone communications and power supply.
- VMS - Installation of full-matrix variable message sign utilizing hybrid flip disk/fiber technology, support structure, sign controller in cabinet, and connecting cables. Also includes conduits for telephone connections



- Route 128 Corridor
- I-93 Operational Test
- Southeast Expressway HOV Lane
- TOC Framingham



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Exhibit 13-1 : Cost Estimate for Phase 1 IVHS Strategic Deployment Plan for Metropolitan Boston

Costing Item	Units	Qty	Unit Cost	Capital Costs	Maintenance (Annual)
DETECTOR STATIONS					
Loop Upgrade	ea	47	\$16,000	\$752,000	\$75,200
New Loop	ea	28	\$30,000	\$840,000	\$84,000
Overhead	ea	54	\$45,000	\$2,430,000	\$121,000
Overheight	ea	3	\$50,000	\$150,000	\$15,000
Park & Ride Lots	ea	16	\$20,000	\$320,000	\$32,000
WEATHER SENSORS	ea	12	\$20,000	\$240,000	\$24,000
CCTV					
40' Pole (single camera)	ea	25	\$40,000	\$1,000,000	\$50,000
100' Tower (dual Cameras)	ea	15	\$100,000	\$1,500,000	\$75,000
Building-Mounted (single camera)	ea	5	\$30,000	\$150,000	\$7,500
VMS					
3-Line	ea	28	\$180,000	\$5,040,000	\$252,000
SUPPLEMENTAL SIGNING					
MP Markers	ea	1360	\$40	\$54,400	\$2,720
Over/Under Pass	ea	144	\$100	\$14,400	\$720
INCIDENT REPOSE					
Teams	ea	4	\$220,000	\$880,000	\$88,000
COMMUNICATIONS					
CSD/DSU	ea	332	\$1,000	\$332,000	\$33,200
Leased TV-1 Circuits	ea	60	\$45,000	\$2,700,000	\$86,400
Local Distrib. Channels	ea	248	\$450	\$111,600	\$111,400
Inter-office Channels	ea	84	\$0	\$0	\$46,200
CONTROL CENTER – MHD					
Installation/Modification	LS	1	\$2,000,000	\$2,000,000	\$100,000
Central Hardware	LS	1	\$700,000	\$700,000	\$105,000
Firmware/Software / Integration	LS	1	\$1,600,000	\$1,600,000	
CONTROL CENTER – TICC					
Installation/Modification	LS	1	\$500,000	\$500,000	\$25,000
Central Hardware	LS	1	\$900,000	\$900,000	\$135,000
Software/Integration	LS	1	\$2,400,000	\$2,400,000	
Other – TOC Hardware/Software	ea	6	\$120,000	\$720,000	\$108,000
Other – TOC Communications	ea	6	\$90,000	\$540,000	\$21,000
Subtotal				25,874,400	\$1,599,040
Engr./Inspection				\$6,468,600	
Contingency (25%)				\$8,085,750	\$399,760
Total				\$40,428,750	\$1,998,800

Exhibit 13-1 (con't) : Cost Estimate for Phase 1 IVHS Strategic Deployment Plan for Metropolitan Boston

Costing Item	Units	Qty	Unit Cost	Operations (Annual)
CONTROL CENTER STAFFING				
MHD Control Center	per	13	\$62,500	\$812,500
TICC	per	11	\$65,000	\$715,000
FREEWAY SERVICE PATROLS				
Contracted	LS	1	\$1,800,000	\$1,800,000

Total \$3,327,500

Exhibit 13-2 : Cost Estimate for Year 2000 IVHS Strategic Deployment Plan for Metropolitan Boston

Costing Item	Units	Qty	Unit Cost	Capital Costs	Maintenance (Annual)
DETECTOR STATIONS					
Loop Upgrade	ea	26	\$16,000	\$416,000	\$41,600
New Loop	ea	91	\$30,000	\$2,730,000	\$273,000
Overhead	ea	122	\$45,000	\$5,490,000	\$274,500
Park & Ride Lots	ea	14	\$20,000	\$280,000	\$28,000
WEATHER SENSORS	ea	14	\$20,000	\$280,000	\$28,000
CCTV					
40' Pole (single camera)	ea	58	\$40,000	\$2,320,00	\$116,000
100' Tower (dual cameras)	ea	17	\$100,000	\$1,700,000	\$85,000
VMS					
3-Line	ea	25	\$180,000	\$4,500,000	\$225,000
SUPPLEMENTAL SIGNING					
MP Markers	ea	4175	\$40	\$167,000	\$8,350
Over/Under Pass	ea	248	\$100	\$24,800	\$1,240
INCIDENT RESPONSE					
Teams	ea	6	\$220,000	\$1,320,000	\$132,000
CSU/DSU	ea	92	\$45,000	\$4,140,000	\$132,480
Leased TV-1 Circuits	ea	456	\$450	\$205,200	\$205,200
Local Distrib. Channels	ea	132	\$0	\$0	\$72,600
METERING					
Ramp	ea	80	\$40,000	\$3,200,000	\$320,000
Mainline	ea	6	\$350,000	\$2,100,000	\$210,000
CONTROL CENTER – MHD					
Central Hardware	LS	1	\$200,000	\$200,000	\$320,000
Firmware/Software/Integration	LS	1	\$1,000,000	\$2,100,00	\$210,000
CONTROL CENTER – TICC					
Central Hardware	LS	1	\$400,000	\$400,000	\$60,000
Software/Integration	LS	1	\$600,000	\$600,000	
Other – TOC Hardware/Software	ea	5	\$120,000	\$600,000	\$90,000
Other – TOC Communications	ea	5	\$90,000	\$450,000	\$17,500
Subtotal Engr./Inspection Contingency (25%)				\$32,711,000	\$2,409,270
				\$8,177,750	
				\$10,222,188	\$602,318
Total				\$51,110,938	\$3,011,588

Exhibit 13-2 (Cont'd): Cost Estimate for Year 2000 IVHS Strategic Deployment Plan for
Metropolitan Boston

Costing Item	Units	Qty.	Unit Cost (Annual)	Operations (Annual)
CONTROL CENTER STAFFING				
MHD Control Center	per	15	\$62,500	\$937,500
TICC	per	8	\$65,000	\$520,000
FREEWAY SERVICE PATROLS				
Contracted	LS	1	\$2,400,000	\$2,400,000

Total \$3,857,500

and power supply.

- Communications - Installation of CSU/DSU for digital telephone interface, plus up-front costs and annual charges for the New England Telephone services.
- Metering - Installation of ramp signal supports, Type 170 (or 2070) controller and cabinet/foundation, and connecting cable. Also includes conduit for power and communications.
- MHD Control Center Installation - Construction of addition to State Police facility, plus interior finish, consoles, and furnishings.
- MHD Central Hardware - Installation of data interface, data base, communications, and VMS servers; workstations, operating system software, printers and peripherals; video hardware (inserters, projection systems, switchers, monitors), and connecting cabling.
- TICC Control Center Installation - Modifications to 10 park Plaza plus interior finish, consoles, and furnishing.
- TICC Central Hardware - Installation of data base, communications, and expert system servers, workstations, operating system software, workstations, printers and peripherals, video hardware (inserters, projection systems, switchers, monitors), and connecting cabling.
- Firmware/Software/Integration - Includes 170 firmware development for detector processing and meter control, software development (algorithms, GUI, Expert System, etc.) and integration with central hardware, and integration of field elements with communications network and central hardware into a fully-operational system. Also includes preparation of response plans (i.e., rules base) and conversion to Expert System.
- Other - Servers, software, integrated workstations, and video intertie hardware at each agency (MHD, MBTA, MTA, MassPort, State Police, municipalities) for TICC connections; and the communication lines. (Note - The communication lines are costed to support video between the TICC and the various agencies.)

Funding

Implementation of the IVHS Strategic Deployment Plan for metropolitan Boston is dependent upon available funding. As with any transportation improvement, IVHS will necessarily complete with other projects for limited transportation sources. Decisions

regarding the allocation of monies rest with various funding agencies, and will be dependent, to a large extent, upon policy decisions made by the regional planning organization. Formulation of a comprehensive financial plan for IVHS will be required once an implementation commitment is made. As project estimates and timelines are adjusted, financial strategies will also require modification. This is especially true since many Federal fund sources cannot be projected beyond 4-5 years time.

IVHS is an ambitious program in terms of costs, project phasing, and multi-agency involvement. Success will ultimately be determined by the level of consensus and cooperation by the various agencies in pursuing funding. Federal funds -- CMAQ and STP along with IVHS operations tests and demonstration money as appropriate -- will be heavily relied upon, requiring State and local funds to leverage and match the CMAQ and STP funding. It is envisioned that MTA and MassPort will fund the IVHS elements on their facilities (e.g., detectors, TICC server, etc.) with toll revenue and related sources. Similarly, MBTA will fund, with assistance from the Federal Transit Administration, additional enhancements to their WI-IS-based systems. (Note - These transit costs are not included in the cost estimates contained in Exhibits 13-1 and 13-2. In addition to the ongoing operations control center enhancement and "T" line AVL endeavor (at a cost of \$25 million), the cost of an AVL upgrade to commuter rail is estimated at \$5-\$10 million and the cost of implementing an AVL system for all 1000 MBTA buses is estimated at approximately \$15 million.)

Public-Private Partnerships

Sole dependence on the existing revenue sources noted above will likely delay implementation either of the full IVHS program described herein, or other transportation initiatives within the region between now and the Year 2000. Thus a new dedicated revenue source may be required. Another alternative is to reduce the cost of the IVHS program without sacrificing system elements, coverage area, or functionality. This may be possible through initiating public-private partnerships.

As previously discussed in Chapter 4, within the context of IVHS, a public-private partnership is one in which a private entity provides some of the IVHS services and/or

system elements included in the Strategic Deployment Plan. But instead of direct reimbursement from the public agency, some or all of the private entity's costs for these functions are recouped by selling IVHS-based services to other private entity's (i.e., collecting a user fee), or by receiving a non-monetary consideration for these services from the public agency (a sort of quid-pro-quo). Potential public-private partnerships which may be pursued within the Boston region include:

- Provide access to the highway right-of-way to New England Telephone for installation of their networks, in return for which the IVHS communications subsystem will be provided at a cost less than tariff (on which the cost estimates are based). As an alternative, the right-of-way may be provided to a communications provider simply for a fee (i.e., additional IVHS revenue source). Key issues with such a partnership include responsibilities (and costs) for maintenance of the networks facilities, and the extent of the right-of-way package (i.e., Boston; or the entire Commonwealth). It is noted that the experience to date in the northeast corridor with this approach has not been encouraging. Most communication companies apparently obtained their necessary rights-of-way years ago; significantly diminishing the value of freeway right-of-way.
- Charge a fee to private entities for accessing the TICC global database. As previously discussed, the market value of such traveler information is unknown. Another alternative is to not charge an access fee, per se, but rather receive a portion of any revenue (or profit) taken in by the private entities from the "resale" of the traveler information. A key issue with this concept is consistency between the various transportation agencies which provide information to the TICC database. It could be an institutional nightmare if one agency wanted to sell the information, but another public agency was opposed to the concept. This concept involves some significant policy questions as well -- for instance, since the infrastructure to collect this information was paid for by the traveling public as taxpayers, is it proper to charge them again for receiving the information?
- Expand the public-private nature of the Department's service patrols program. Samaratania was awarded the contract to operate the 16 service patrol routes in the Boston area; but due to additional funding from CVS (in return for their name on the vehicles), 20 vehicles will be patrolling the roadway network. Perhaps such leveraging can be increased, with both MHD and the private entity's name on the van.
- Provide exclusive towing rights along freeway segments to wrecker companies for a fee. This is used by the New York Department of Transportation. The

- y Long Island parkways have been divided into sections, and contracts for towing and emergency road service within each section are awarded on the basis of highest bid. These contracts are exclusive -- no other wrecker company may operate on the parkways within the particular section. The successful bidder must meet several qualifications, including: 24-hours-a-day, 7-days-a-week response; operate a registered vehicle repair shop within the sector (although the contractor cannot require that a vehicle be towed to his/her premises, but shall tow to any facility designated by the driver of the towed vehicle); a minimum of two suitable towing vehicles; respond within 30 minutes of receiving a call from police or NYDOT; and clean up debris at the incident scene. The maximum rates that can be charged by the towing company (to the driver) are set by the Contract.
- Sell advertising on traveler information components such as transit station kiosks and roadway variable message signs (refer to Exhibit 13-3). The basic concept is to have a private entity install and maintain kiosks or VMS assemblies, subject to public agency criteria and guidelines. There will be no reimbursement to the VMS vendor/installer by the government agency; instead, the private entity will recoup its costs by selling advertising on the signs. There are admittedly many concerns with this concept in terms of the impact of traveler-related messages and potential accidents (i.e., drivers averting attention from the roadway). However, if privatized VMS can be implemented with minimal impacts on the sign's effectiveness or on driver safety, then this approach may offer significant cost savings.
 - Turn over the day-to-day operation of the regional TICC to a private entity. This privatized TICC would perform most of the functions previously discussed (e.g., integrate the data from the various agency's systems, function as an information clearinghouse for these public agencies, develop and operate the prearranged coordination mechanisms providing TICC staff, etc.) at little or no cost to the public transportation and enforcement agencies. In return for these services, the private entity would likely be given exclusive rights to the information under a franchise agreement, and could sell the information to other private entities (e.g., radio, TV, fleet operators, in-vehicle systems, etc.) for dissemination to traveling public. This approach involves several issues, including how the franchise is awarded and renewed, oversight of the franchise, and levels of public agency control.

The entire subject of public-private partnerships involves several legal and operational issues. But the ones noted above and others merit further investigation.

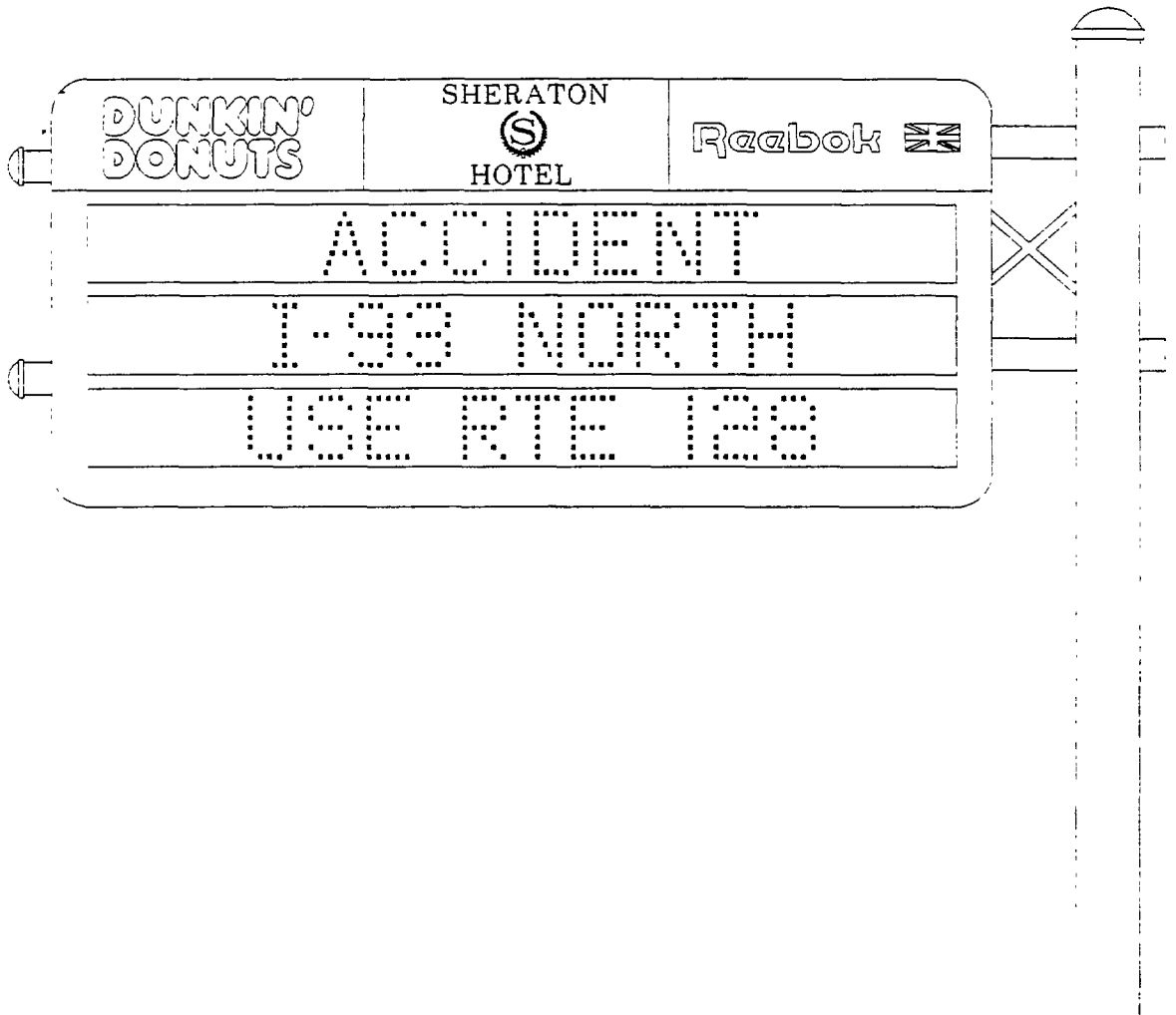


Exhibit 13-3, Privatized VMS Mock-Up

BENEFITS

IVHS and the associated technologies and strategies are not ends in and of themselves. The purpose for investing public funds in an IVHS deployment program is to obtain benefits -- to reduce congestion, improve safety and air quality, and enhance the mobility and economic competitiveness of the Boston region. There is a need for such improvements. Congestion on the Boston area expressway network is estimated (according to a FHWA study) to increase from 44.8 million vehicle-hours of delay in 1987 to 238 million vehicle-hours of delay in 2005. Correspondingly, the annual excess fuel consumption is predicted to increase from 52.5 million gallons to 253.4 million gallons during the same time period.

IVHS networks have proven to be one of the most cost-effective methods for reducing congestion and improving the operation of the transportation network. A study by FHWA has identified significant benefits resulting from the implementation of systems such as the one recommended for the MHD roadway network, including an average 37 percent reduction in incident-related delay, an average 28 percent reduction in recurring delay, and an average 22 percent reduction in excess fuel consumption. Some of the reported and projected benefits of M-IS in the form of reduced travel time, delay, vehicle hours of travel, safety, and pollution are summarized in Exhibits 13-4 and 13-5. Similar results may be anticipated in Boston. Moreover, these "quantifiable" benefits do not begin to address the improved mobility afforded by IVHS.

An air quality analysis was performed to assess the potential benefits associated with the implementation of the recommended IVHS program. The results of this conservative analysis for the Phase 1 area indicated reductions of approximately 190 KG/day in volatile organic compounds, 1000 KG/day in carbon monoxide, and 40 KG/day in nitrous oxides. The additional air-quality savings associated with the Year 2000 Plan are 120 KG/day in volatile organic compounds, 820 KG/day in carbon monoxide, and 50 KG/day in nitrous oxides.

Exhibit 13-4: Reported Benefits of Implementing IVHS Technologies and Strategies

System	Congestion	Pollution/Fuel	Safety
Advanced Signal Control System			
ATSAC system Los Angeles, CA ²⁵	13.2% reduction in travel time.	12.5% reduction in fuel consumption. 10.2% reductions in hydrocarbon emissions. 10.3% reduction in carbon monoxide emissions.	
TOPICS III, VTCS Expansion ²⁶ New York, NY	13% increase in average speed. 23% reduction in overall delay. 23% reduction in stops.	9.3% reduction in Fuel consumption. 14.7% reduction in carbon monoxide emissions. 14.2% reduction in hydrocarbons. 13.4% reduction in nitrous oxide.	
Freeway Ramp Metering System²⁷			
Minneapolis and St. Paul, Minnesota	35% increase in average peak period freeway speed. 32% increase in-peak period traffic volume.		27% decline in number of peak period traffic accidents. 33% decline peak period accident rates.
SCANDI, Detroit., Michigan	8% increase in speed.		.50% in the total number of accidents and 71% reduction in injury accidents.
INFORM, Long Island, New York Analysis of initial metered segments		6.7% reduction in fuel consumption. 17.4% reduction in carbon monoxide and 13.1% reduction in hydrocarbon emissions.	
FLOW, Seattle, Washington (1981- 1937)	Travel time on 6.9 mile stretch of I-6 was reduced from 22 minutes to 11.5 minutes. 36% increase in peak period northbound traffic volume and 62% increase in peak period southbound traffic volume.		

Exhibit 13-4: Reported Benefits of Implementing IVHS Technologies and Strategies (continued)

System	Congestion	Pollution/Fuel	Safety
INFORM, Long Island, New York ²⁸ Ramp Metering	13% increase in peak period speed. 5% increase in vehicle miles traveled. The congestion index (percentage of detector stations with speeds less than or equal to 30 mph) was reduced by 60% for AM peak hours and 36% for PM peak hours.		
INFORM, Long Island, New York Analysis of ²⁹ initial metered segments	The estimated annual delay savings for the incident-related effects of the variable message signs is 300,000 vehicles hours.		

Exhibit 13-5: Projected IVHS Benefits

System	Congestion	Pollution/Fuel	Safety
Advanced Signal Control System			
OKI - RTMS ³⁰	For a typical incident, the proposed system would reduce the total delay by about 274 Vehicle Hours Travelled.	For a typical incident the proposed system would reduce emissions of hydrom carbon by 7 KG and carbon monoxide by 64 KG.	
FLAMINGO, Florida ³¹	Incident Management Strategies could save 316,000 VHT/year. Installation of Ramp Metering could save 3676 hours of vehicles delay day.		
Smart Corridor System ³²	11% to 16% reduction in total travel time in the corridor.	2% to 3% reduction in fuel consumption in the corridor. 8% reduction in hydrocarbon emission in the corridor. 16% reduction in carbon monoxide emissions in the corridor.	
Academic Studies on Motorist Information System ³³			
RACS Project in Tokyo, Japan Study by Tsuji	3% to 14% savings in travel within urban conditions.		27% decline in number of peak period traffic accidents. 33% decline peak period accident rates.
Autoguide Project in London Study by Smith and Russam	6% savings in travel time.		63% in the total number of accidents and 71% reduction in injury accidents.
A Corridor in Austin, Texas Study by Jones, Mahmassani, et.al.	16% to 30% reduction in travel time through route changes. 10% to 2% reduction in travel time by departure time switching.		
Congested Hypothetical Network Study by R&ha, Van Aerde, etc.	23% reduction in travel time.		

AGREEMENTS

Agreements between the participating agencies will be an essential part of the implementation and operation of the Boston area IVHS network. This is particularly true for the regional TICC due to the multitude of jurisdictions that would be involved with the system, coupled with the clearing house and coordination functions of the TICC. These agreements will serve a variety of institutional and organizational needs, including:

- Provide a joint statement of support recognizing the need for the TICC.
- Delineate the respective responsibilities of each of the participating agencies.
- Identify the TICC elements and functions, and assign responsibility for those elements.
- Identify the mechanisms that will be used to oversee and coordinate the planning and operational aspects of the TICC.
- Identify the financial and labor resources that will be provided by the participating agencies to support the TICC.

To develop an understanding of how the difficulties of obtaining interagency agreements and approvals were surmounted in other parts of the country, a review was performed of several of the agreements used by agencies that are already involved in the operation of freeway management systems. These reviews revealed that there are several distinctly different types of agreements.

In California and in Houston, Texas there are documents that provide basic agreements between the participating organizations. These documents are the CHP and Caltrans “Joint Operational Policy Statement”, and the “Agreement for the Houston Area Freeway Incident Management Program”. Although these documents are different in many ways, they both provide a fundamental definition of the relationships between the participating organizations.

A second type of document provides a more detailed description of the operational practices and operational policies and procedures that should be followed in very specific situations. Examples of these documents include:

- Removal of Vehicles from Highways (Maryland)
- Interagency Special Event Service Agreement (Maryland)
- Interagency Work Zone Traffic Control Agreement (Maryland and California)
- Bomb Search Agreement (California)
- Cross Communications Agreement (California)
- Hazardous Material Spill Cleanup Responsibility (California)

The existence of these documents presents a strong case for avoiding an approach in which a single document tries to satisfy all of the requirements of participating agencies. In keeping with this finding, the recommended approach for the Boston area is to develop a series of interagency agreements covering different levels of detail and different aspects of the program.

Recommended Agreements

Following are descriptions of agreements necessary for the implementation and operation of the TICC.

General Agreement

The first of the agreements should be an overall general agreement between all of the public agencies participating in the TICC. The agreement should include the following points or sections:

- Section 1 - A preamble stating the premise of the TICC and the general purpose of the agreement.
- Section 2 - This section identifies the major elements of the TICC, its functions, and areas of coverage.
- Section 3 - This section establishes MHD as the organization responsible for the implementation of the TICC, and the organization which will be responsible for operation of the system.
- Section 4 - This section establishes the TICC Steering and Executive Committees which will oversee the development of response plans and the overall management of the TICC.
- Section 5 - The organizations which will be responsible for funding the implementation and operation of the system should be indicated.
- Section 6 - Signatures.

Funding Agreement

Following the initial general agreement, a separate agreement would be signed by all of the agencies responsible for funding the implementation, operation and maintenance of the TICC. This agreement should contain the following sections:

- Section 1 - Identify the parties to the agreement.
- Section 2 - Preamble.
- Section 3 - This section contains a general statement of the agreement, identifies the major elements of the program, assigns responsibility for the elements, sets the terms of the agreement and the renewal procedures, and provides for funding of the initial term of the agreement.
- Section 4 - Signatures.
- An Appendix would contain the details of the funding for the initial term and the supplementary notes.

Joint Operating Agreements

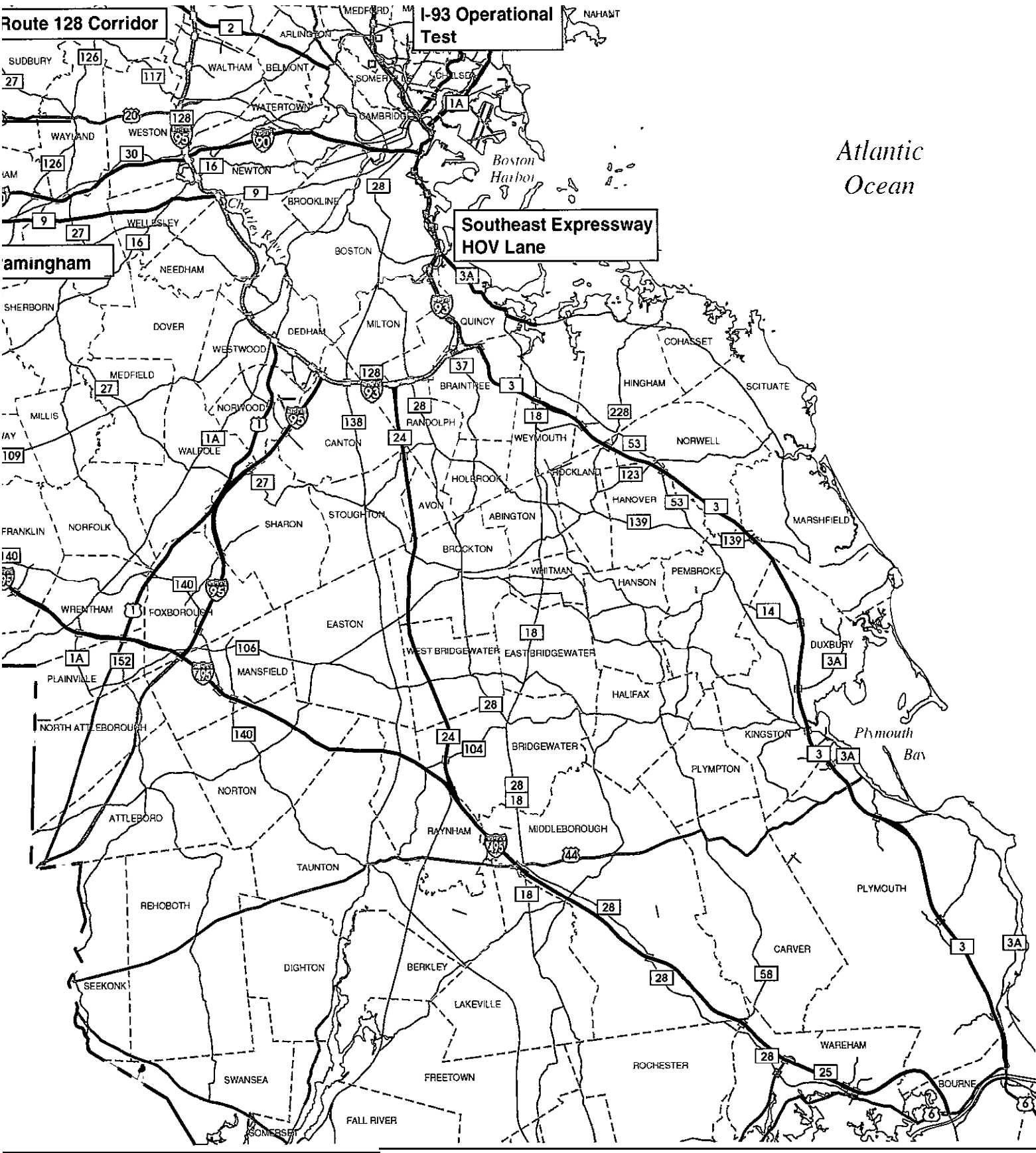
It is anticipated that a series of joint operating agreements will be executed between MHD and each of the various involved agencies. These agreements would cover more details of the operation of the TICC and the specific responsibilities of the various agencies. Issues to be addressed in these agreements include:

- Reporting of incidents detected by TOCs to the TICC.
- Procedures for obtaining video images (from CCTV subsystem) and camera control.
- Procedures by which jurisdiction may request specific messages for displayed on VMS.
- Responsibilities for notifying response services (e.g., fire, wreckers, ambulance, etc.)
- Procedures for implementing diversion on jurisdiction-controlled roadways.
- Responsibilities for notifying media regarding roadway and transit conditions.
- Procedures for changing signal timing on arterial streets.
- Standards to be adopted (e.g., GIS, database management) as appropriate.

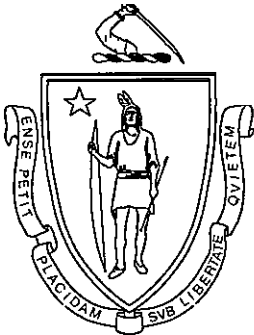
IMPLEMENTATION PHASING

As previously discussed, the deployment of the Boston area IVHS network has been divided into two implementation phases -- Phase 1 and Year 2000. These phases do not, however, represent single projects. Each phase will involve multiple projects. For example, implementation of the Phase 1 Plan will include the following projects as shown in Exhibit 13-6.

- Early Action Incident Management Program - This project covers the Route 128 corridor between Route 28 in Wakefield and the Route 3/I-93 interchange in Braintree; and includes the deployment of detectors, cameras, and VMS within the corridor, the initial MHD-TOC at the State Police communications



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ay HOV Lane



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center, and the associated communications network.

- I-93 Corridor in Medford, Somerville, Cambridge, and Boston - In addition to the installation of detectors, cameras, and VMS along this segment of the freeway network, the project also includes integration with the surface street network (e.g., detectors, signal systems) and MBTA parking.
- Southeast Expressway Corridor - This project includes the installation of detectors, cameras, and VMS in conjunction with the proposed HOV facility.
- Other - One or more projects will be implemented to complete the Phase 1 VMS network. In addition to the remaining roadway segments, these projects will also include the weather detectors, overheight sensors, supplemental guide signs, and the initial TICC.

Additionally, the Phase 1 effort will include preparation of the necessary agreements between MHD and the other transportation agencies regarding staffing and operation of the TICC, and a public relations and information program to promote the proposed IVHS improvements within the Boston area, including future ramp metering.

IMPLEMENTATION APPROACHES

There are three basic approaches which should be considered for deploying the IVHS network -- the engineer/contractor or turnkey bid, program manager, or design/build. The following is a brief discussion of the alternatives.

Engineer/Contractor

This procurement has traditionally been used by most transportation agencies, including implementation of the IPCS. Typically, an engineer prepares a single set of contract documents (PS&E) for the proposed system. For the freeway system project, a specialty consultant is generally used. The contract documents are then advertised, bids are received from contractors, and the project is awarded to the lowest responsive bidder. The winning contractor is responsible for providing a complete and fully operational system, including furnishing and installing all hardware and any required software, system

integration efforts, training and documentation, and in some instances, the development and implementation of operations plans. The consulting engineer often continues his/her activities during system installation by monitoring the contractor's progress, reviewing contractor submissions, participating in the system testing, providing interpretations of the plans and specifications, and developing system database and operations plans if not performed by the contractor. The engineer may also provide training.

With the engineer/contractor approach, there is generally only one contract to prepare and administer. However, no single prime contractor possesses the necessary experience and qualifications to perform all of the work included in the typical freeway management turnkey systems contract. For example, electrical contractors do not have electronics engineers or programmers on staff for developing and integrating technology elements and software. Similarly, a systems firm is not capable of installing conduit and pulling cable. The prime contractor for a turnkey systems project must, therefore, subcontract a significant portion of the work, and the subcontractors may in-turn subcontract portions of their work.

The prime contractor is contractually responsible for the work and the actions of the subcontractors and equipment suppliers. How well the prime (i.e., responsible entity) coordinates and manages its subcontractors is, therefore, critical to the project's success. Administering multiple layers of subcontractors and suppliers is difficult even under the best of circumstances. It requires good human relations, technical expertise, and familiarity with the type of work being performed by the subcontractors. The Boston area IVHS project encompasses a wide range of technologies, equipment, construction techniques, and related services. The prime contractor may not have sufficient knowledge of some of these elements to select appropriate or qualified subcontractors, and then to effectively administer and control their actions. The prime contractor will depend principally on bid price for selecting subcontractors and will place specification adherence responsibility on the subcontractor and in-turn, the administering agency.

Another importance consideration with turnkey project is what type of firm should be prime. Often, the majority of the project's dollar value involves field construction and electrical work, in which case it may be best to have an electrical contractor as prime. However, with this arrangement, the administering agency may not be able to deal directly

with the electronics and systems subcontractors -- the firms hired by the prime contractor to develop the equipment, related software, and to integrate the system. Interaction between the agency and the organizations developing the technology elements is very important for success.

In the engineer/contractor approach, the administering agency generally retains the primary responsibility for ensuring conformance with bid documents and for testing and accepting system elements. The agency is also generally responsible for coordination between contractors working on various phases of the overall program. For the Boston project, this would involve various engineering firms performing final design as well as the construction contractors and suppliers.

Program Management

With this approach, a program manager becomes the responsible entity. The activities of the program manager typically include preliminary design and program definition, preparation of standard bid documents, preparation of final bid documents or supervision of others preparing final design, construction engineering and inspection or supervision of others performing these services, development of any required software, procurement of software-dependent hardware, system integration, operations plans and training and documentation. Overall program management and quality control is also provided. The contract between the agency and the program manager is typically a negotiated agreement for engineering services similar to design and other consultant contracts.

Instead of single turnkey contract, several contracts for the various subsystems are prepared. Examples of these separate subsystem contracts might include construction of control center facility; procurement of computer hardware; installation of VMS and sign support structures; and field electrical work (e.g. detectors, CCTV, ramp meters, etc.). The agency's normal procurement processes are generally used to procure the individual subsystems and services; however, the program manager can also serve as a contracting entity. The program manager may administer these contracts and is responsible for integrating the various subsystems into an operating system. The program manager also

controls technical specifications and standards throughout the construction phases even where design work is done by others.

A distinct advantage of the program management approach is that the overall system design, software development, and system integration and testing activities are all controlled by a single entity -- the program manager who in turn is under the direction of MHD. This provides continuity throughout the process as well as a single source of responsibility and accountability. This "responsible entity" cannot blame its problems on the overall designer as they are one-in-the-same. It is essential that the program manager be qualified to perform the various program management activities, and that it have the proper facilities for system design, development, integration, testing, training, and operational support.

Another potential benefit of the program management approach is that the engineering agreement between the owner (i.e., MHD) and the program manager is generally negotiated. This allows both parties to jointly determine the scope of work, define their respective duties and responsibilities, develop a realistic estimate to the corresponding costs, and to fully understand what is required for the system before the work actually commences. Experience has also shown that these engineering agreements for program management offer the agency more flexibility over time as compared to the less flexible requirements of turnkey contracts.

When multiple contracts are used, as they generally are with the program management approach, it is critical that all necessary components be included in the various contracts. For example, if one contract covers installation of changeable message signs and another contract addresses the sign support structures, then one of these contracts must also include power service conduit. Putting a particular component in the wrong contract can also cause problems. For instance, the procurement of complex communications equipment and other high-technology items probably should not be included in a field construction contract. Similarly, the supplier of sophisticated systems equipment is not best suited to install foundations or conduit.

Proper sequencing and coordination of the various subsystem contracts is critically important during a project of the scale of the Boston IVHS program. This project management and coordination activity is one of the major responsibilities of the program

manager, and is a significant factor affecting project success.

The program management approach, also sometimes referred to as an extension of systems management, has been used for the successful implementation of several major freeway surveillance system projects. It was developed in response to problems in implementing traffic control systems under the engineer/contractor approach.

Design/Build Approach

In the design/build approach, a single responsible entity is selected to perform all work associated with the deployment of the system. The agency's sole role is in monitoring the activity of the design/builder. The design/builder performs all design work, contract and/or constructs system elements, commissions the system and turns it over to the operating agency.

In the United States, the design/build approach has most often been applied to buildings and to Department of Defense procurements. One or more firms develop a conceptual plan for the building (such as government center, a hospital, or a prison) or defense system and the concept is selected. The firm then carries the design through preliminary engineering or design, generally expressed as the "30 percent design level". Negotiations are then conducted for the final cost of construction. This may be done as fixed amount or on the basis of unit prices for estimated quantities with payment on actual quantities. As a note, design/build is used extensively for transportation projects outside of the United States. After the agreement is negotiated, the design/builder completes all aspects of the project in conformance with the preliminary design. Changes are generally negotiated similar to a turnkey contract. There are no direct models for the Boston area IVHS application.

A key attribute of the design/build approach is the complete transfer of responsibility to the design/builder. This generally allows the project to be completed more quickly in that procurement procedures can be streamlined and problems can be resolved quickly. Also, the design/builder is under significant incentive to complete all work quickly and turn the system over to the agency to reduce costs and risks.

The approach does place a burden of supervision on the agency to insure that quality is maintained in that the design/build moves at full speed and is reluctant to change directions. This offers some difficulty in coordinating with technology/changes. It also may force the agency into making decisions quicker than they are comfortable with.

Summary

The program manager approach appears to offer the greatest promise for implementing the Boston IVHS network. The program manager, selected on the basis of technical merit, offers the technical and administrative skills needed for the work without requiring MHD to recruit and dedicate the required skills. The use of program management also offers the opportunity to streamline some of the administrative and procurement procedures to reduce time to deploy. Strong coordination of the technical elements of the project at a single point will also facilitate incorporation of new technologies and coordination.

The design/build approach also offers benefits, primarily in the time to complete and the transfer of major responsibility to a third party (e.g., contract operations and maintenance). The engineer/contractor approach, with its built-in review and processing time, and use of low bid only contractors for integration and technical development tasks, appears to offer the greatest risk for the Boston project.